Investigating local controls on temporal stability of soil water content using sensor network data and an inverse modelling approach

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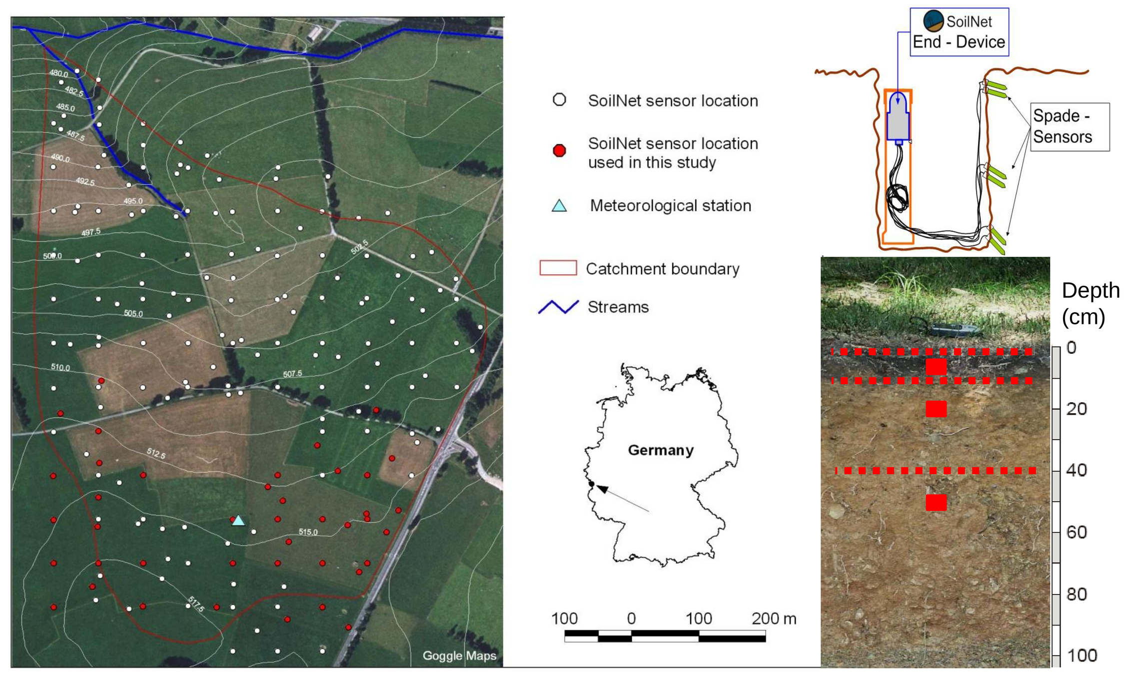
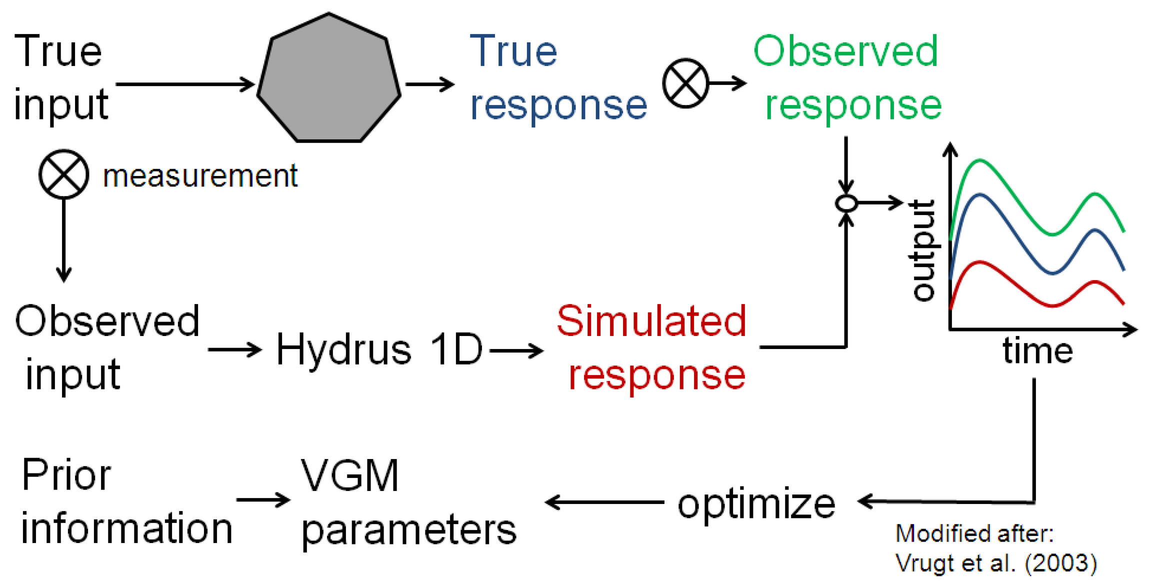
Introduction

Soil water content (SWC) is strongly variable both in space and time. A better understanding of the local and nonlocal controls on SWC is a major challenge in modern hydrology. To this end, we employed an extensive wireless sensor network[1] to measure SWC variability in a small grassland head water catchment and to investigate the importance of local controls on SWC temporal stability. For this we coupled the HYDRUS-1D model with shuffled complex evolution (SCE)[2] algorithm to optimize Mualem-van Genuchten (VGM) parameters (θ_r, α, n and K_s) from SWC observations at three depths under natural (transient) boundary conditions.

Test site



Inverse model approach



Statistical analysis

Relative difference (RD) of soil water content ($\theta_{i,j}$) for location i at time j:

$$RD_{i,j} = \frac{\theta_{i,j} - \bar{\theta}_j}{\bar{\theta}_j}$$

The mean relative difference (MRD) for location i:

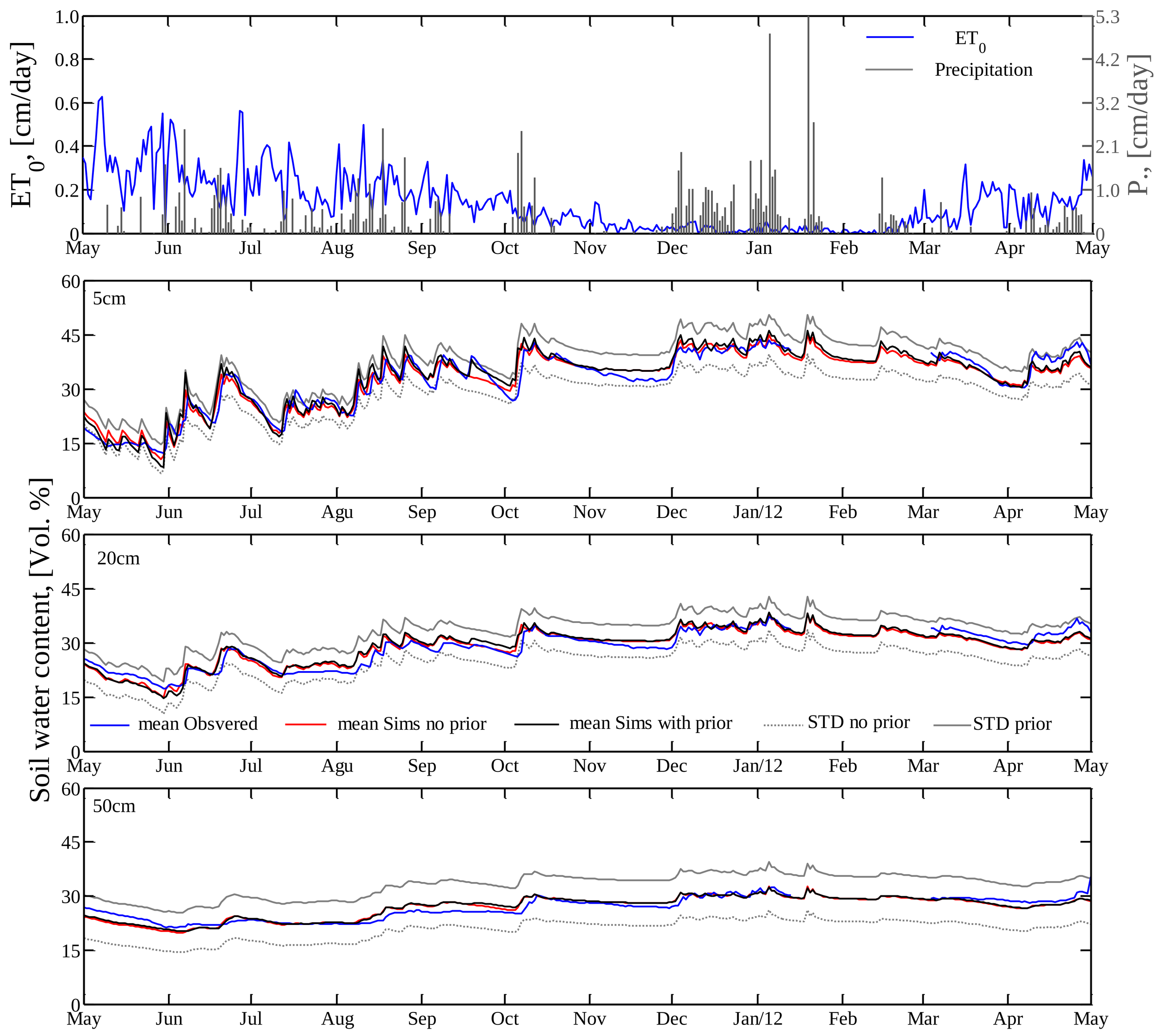
$$MRD_i = \frac{1}{T}\sum_{j=1}^{T} RD_{i,j}$$

Standard deviation of the relative difference (SDRD) for location i:

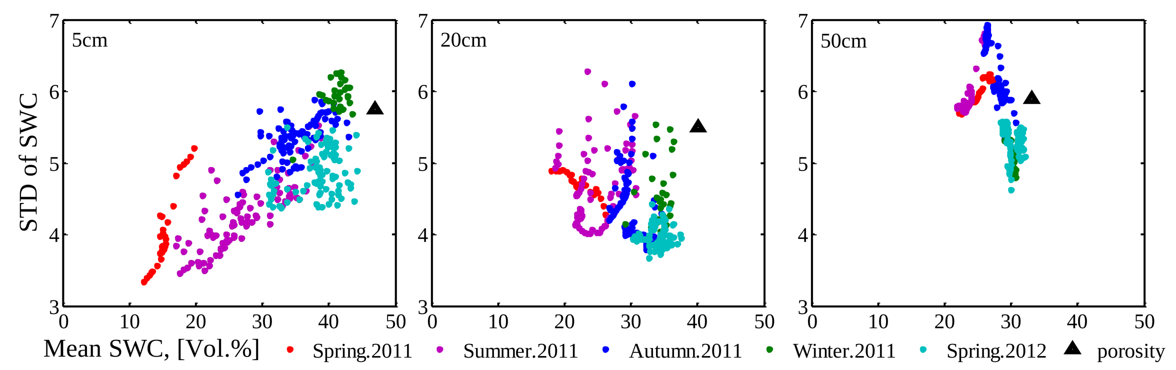
$$SDRD_i = \sqrt{\sum_{j=1}^{T} \frac{\left(RD_{i,j} - MRD_i\right)^2}{T-1}}$$

Results

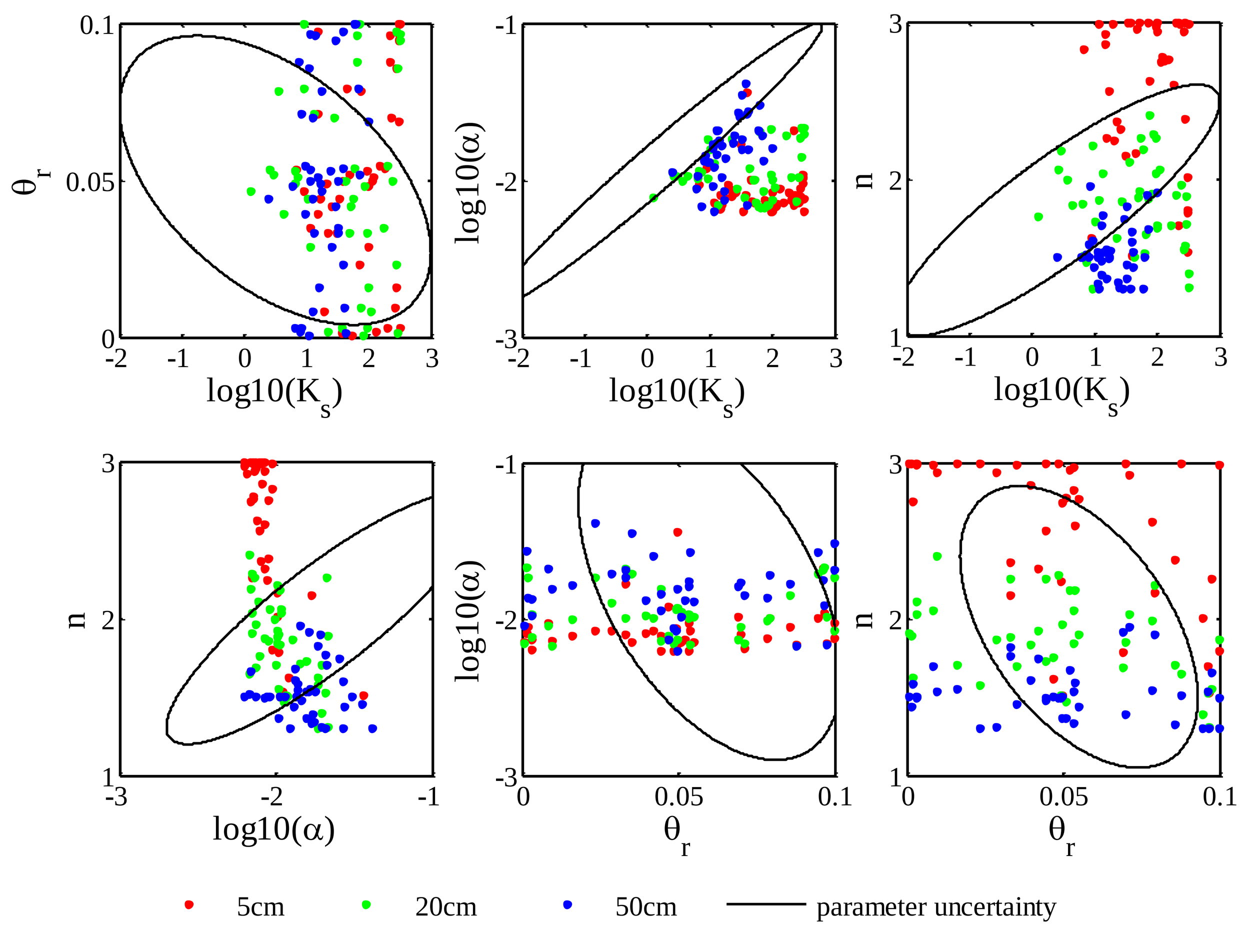
Observed and simulated SWC (1th May 2011 ~ 1th May 2012)



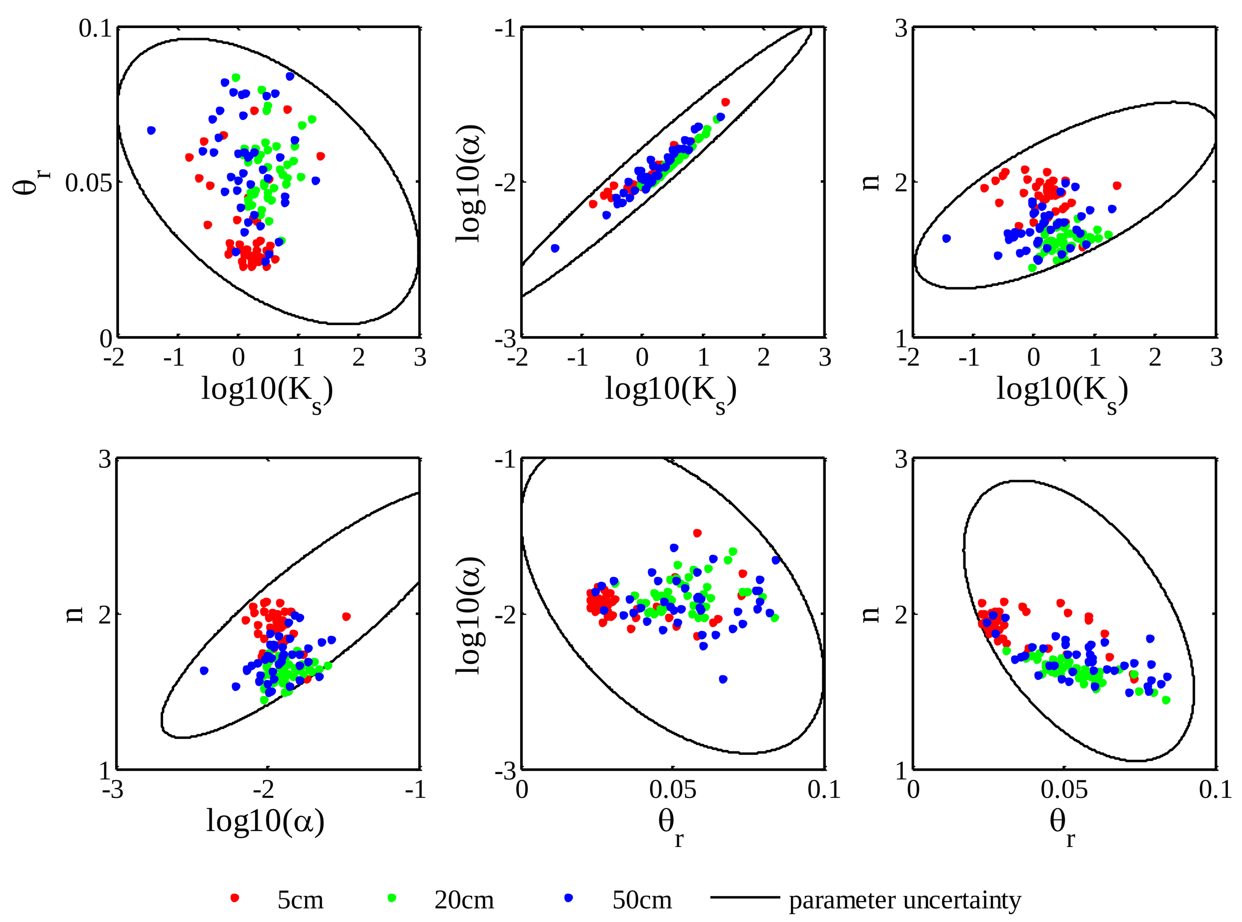
Spatial variability of observed SWC



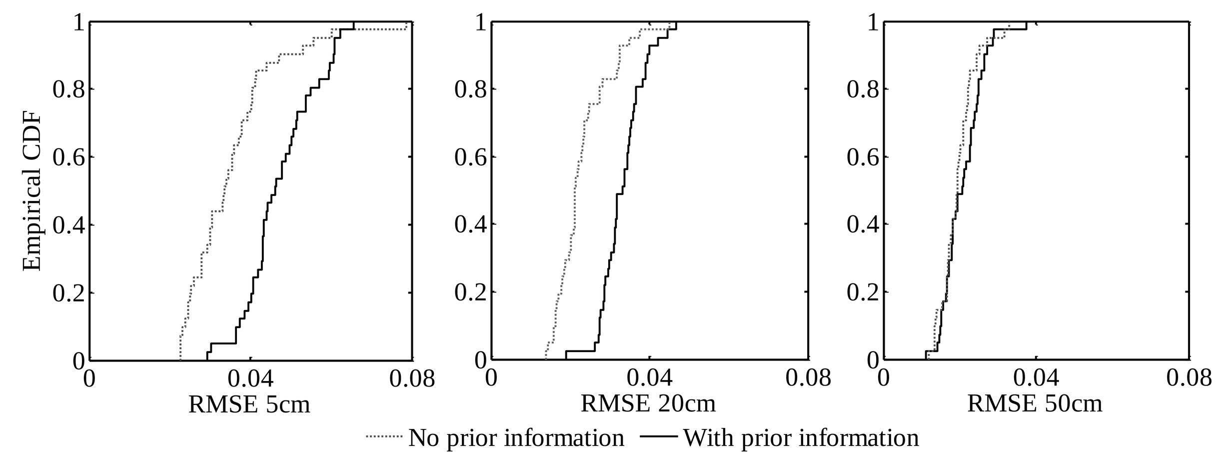
VGM parameter distribution: no prior information



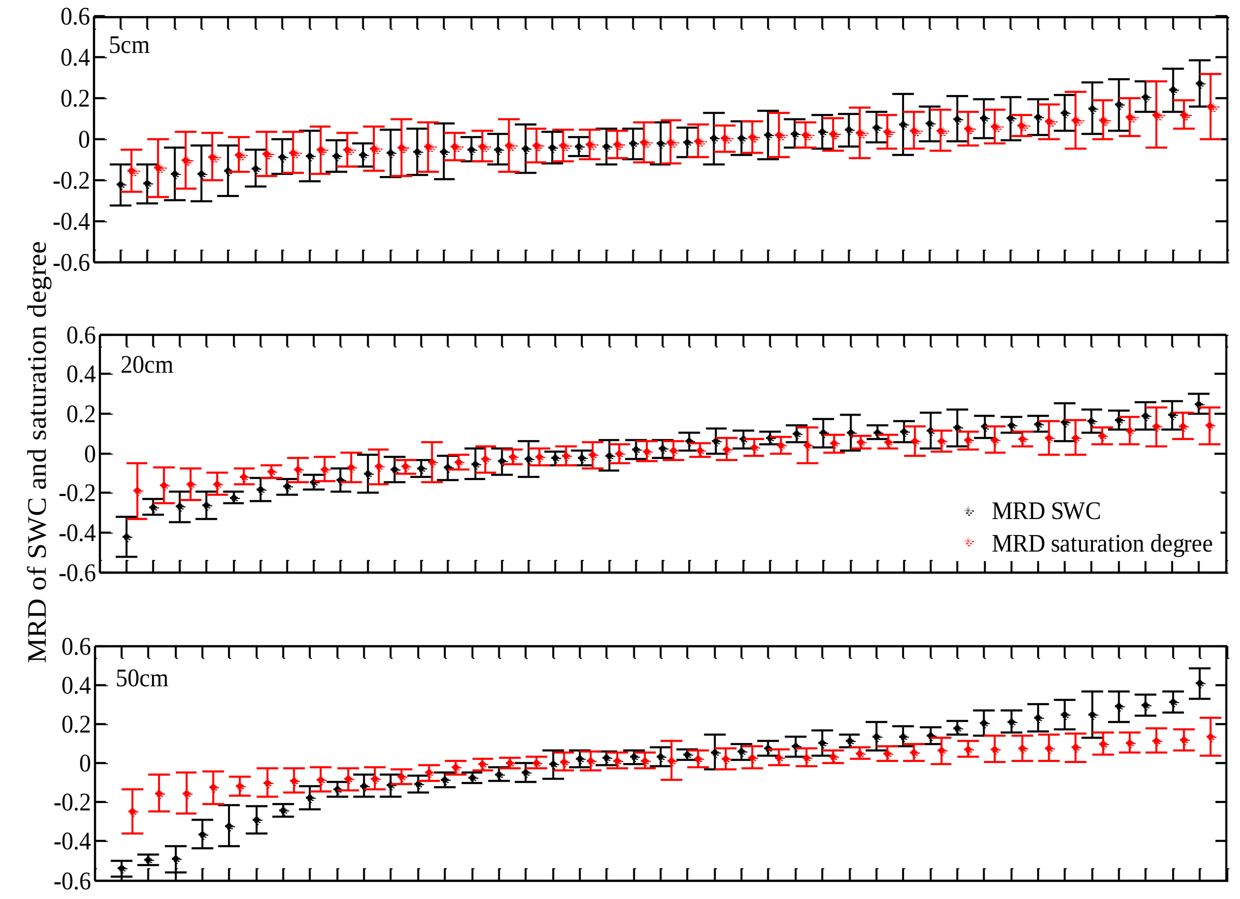
VGM parameter distribution: prior information



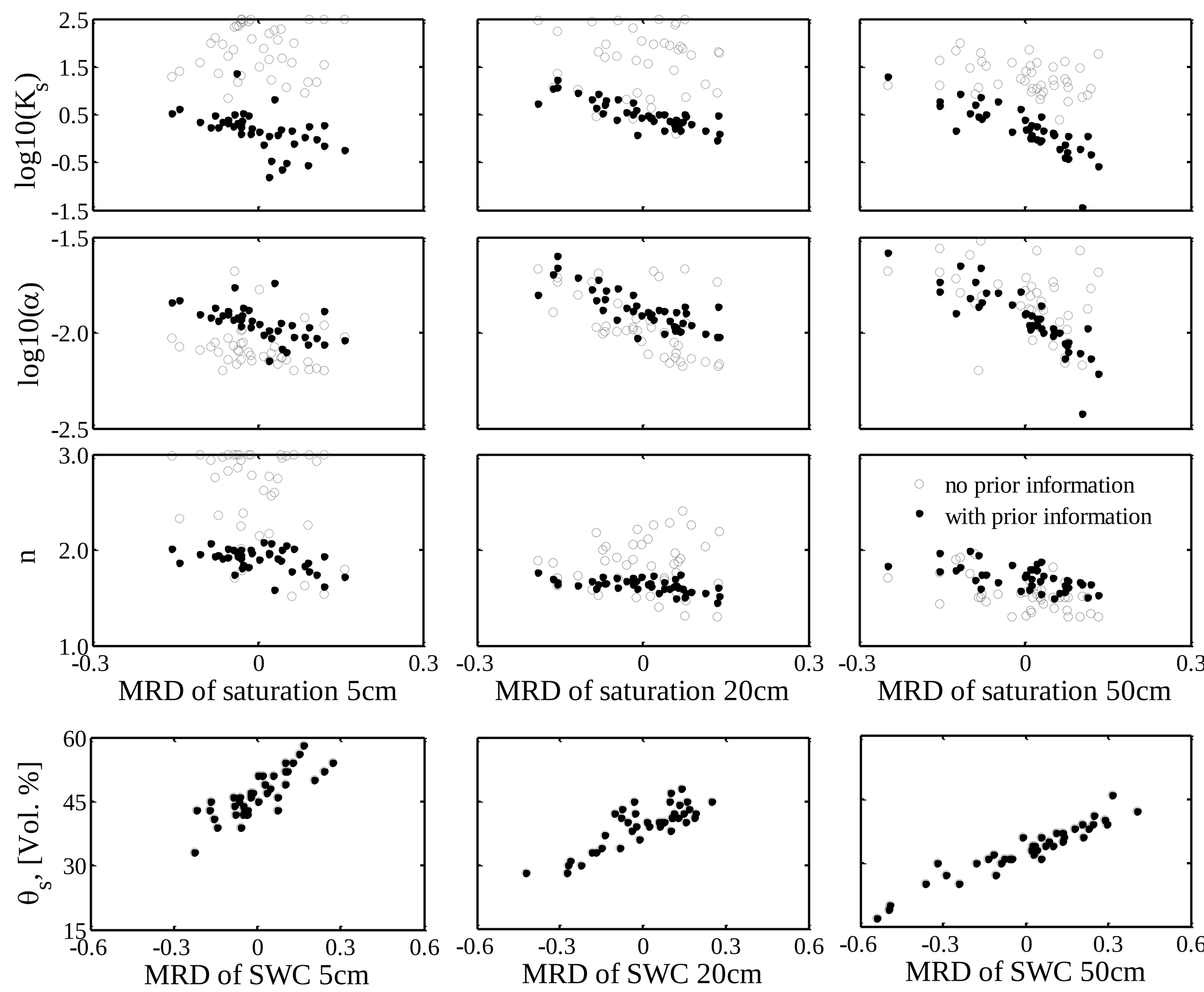
Fitting quality of the SCE: two cases



MRD of SWC and saturation degree



Correlation between MRD and VGM parameters



Conclusions

I. The inversely calibrated HYDRUS-1D model was able to reproduce the observed time series of SWC reasonably well for both optimization strategies.

II. We found linear relationships between the mean relative difference (MRD) of SWC and θ_s.

III. The VGM parameter $log_{10}(K_s)$, n, and $log_{10}(\alpha)$ were strongly correlated with the MRD of saturation degree for the prior information case.

IV. These results indicate the possibility to infer directly the variability of soil hydraulic properties from temporal stability studies of soil water content.

Reference

1. Qu, W., Bogena, H. R., Huisman, J. A., et al. (2013), Calibration of a novel low-cost soil water content sensor based on a ring oscillator: Vadose Zone Journal, 12, doi:10.2136/vzj2012.0139.
2. Vrugt, J. A., Gupta, H. V., Bouten, W., et al. (2003), A shuffled complex evolution metropolis algorithm for optimization and uncertainty assessment of hydrologic model parameters: Water Resources Research, 39(8).

Acknowledgements

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